Mapping Canada's North: An integrated approach

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Abstract

Complete topographical mapping coverage of Canada's North is essential as a basis for the sustainable development of its resources. The unmapped areas in Nunavut and the Northwest Territories amount to over 800,000 square kilometres, equivalent to about 1,500 map sheets at a scale of 1: 50,000. In 2003 a northern mapping project was launched. The essential thrust of this project was to develop Natural Resources Canada's capabilities for gathering digital topographical data at a scale of 1: 50,000 and Canadian Digital Elevation Data (CDED) in Northern Canada. In order to explore all possible scenarios for completing the unmapped areas, the Centre for topographic information (CTI) worked closely with the Canadian Space Agency (CSA) and the private sector on various feasibility tests. After investigating multiple data sources, existing air photography and Landsat 7 imagery were chosen for planimetric data acquisition, and interferometric pairs of ERS 1-2 tandem data was chosen for CDED acquisition.

In 2004, mapping contracts, including the production of CDED Digital elevation models (DEMs), were carried out on test sites in compliance with standards and specifications for planimetric and altimetric production. Results demonstrate that planimetric and elevation data have accuracies of 20 and 10 metres at a 90 percent confidence level respectively.

These tests lead to experimental production in late 2004 for 21 planimetric and CDED data sets which were chosen according to priorities set by major stakeholders and the governments of Nunavut and the Northwest Territories. Priorities are revised annually with these users and a 5 year plan has been set for massive production. In 2005-2006, 88 CDED data sets will be produced and available on the GEOBASE portal.

Introduction

This new mapping project began in 2003, addressing some of Natural Resources Canada's main issues such as: a clean environment, strong and safe communities, sustainable development of natural resources, development of the North, aboriginal people.

Between 2003 and 2006, the Centre for Topographic Information Centre in Sherbrooke (CTIS), Quebec, ran, under the Canadian Space Agency (CSA) Government Related Initiatives Program (GRIP), a project aimed at new base mapping at a scale of 1: 50,000 for unmapped areas of Northern Canada with Earth Observation data. After the first two years, CSA funding for R&D decreased as NRCan's contribution for production increased. NRCan's Mapping Service Branch is presently investing over $400,000 annually for the production of new base mapping in the North.

Feasibility study:

Digital topographic data acquisition is divided in two aspects: planimetry and altimetry. Such is the way various tests were contracted out to private industry. Data was produced in conformity with planimetric specifications and altimetric data acquisition based on product specifications for Canadian Digital Elevation Data (CDED) and Canadian Geospatial Data Base (GDB) standards.

The investigated technologies were conventional stereo-compilation with fifty year old 1: 60,000 scale air photography. Radargrammetric approach with Radarsat-1 data in standard mode was also tested in 3D for planimetry and altimetry, and autocorrelation mode for altimetric data extraction. Altimetry was also tested by interferometry with ERS and Radarsat data. Earth observation technologies such as ASTER, SPOT, IRS, IKONOS, QUICKBIRD, ORBVIEW, EROS, SRTM, were not investigated for different reasons such as: price, availability, resolution or distribution rights.

Test sites were chosen following consultation with various local organizations such as the Nunavut's Geosciences Centre and Sustainable Development Department. They are also representative of northern environments. The first site is located in the Clyde River area on northern Baffin Island, covering four map sheets (27F/13, 27F/14, 27G/03, 27G/04) and was chosen for planimetric data extraction with Landsat 7 imagery and planimetric/altimetric data extraction from radargrammetry. This site is located in a mountainous region and is not suited for altimetric data extraction by interferometry. A second site (map sheet 48G09) located on Devon Island served for this type of extraction.

Results:

Planimetry was analysed for content and accuracy. Several tests were conducted with different technologies (Landsat 7 in 2D mode, Landsat 7/Radarsat in 3D mode, Radarsat in 3D mode) and compared with stereo-compiled air photography in different types of terrain (flat, moderate, mountainous). In this case, stereo-compiled air photography served as ground truth information. Table 1 resumes the results obtained in terms of major conclusions for each method tested.

Table 1: General conclusions for planimetry

Method	Major considerations	Accuracy CE90(metres)
Air photography	- Most detailed content - Needs updating	20
Landsat 7 (2D)	- Detailed content - Interpretation problems with Linear hydrographic features and wetlands (35% are seen)	35
Landsat 7/Radarsat (3D)	- Same as Landsat 7	33
Radarsat (3D)	- Many content errors	108

Altimetry was analysed for accuracy, and coherence with hydrography and terrain.

Method	Major considerations	Accuracy LE90(metres)
Air photography	- Accurate and very good conformity with terrain - Needs updating	10
Radarsat (3D)	- Poor conformity with terrain	42
Radarsat Interferometry	- Poor conformity with terrain - Inaccurate in mountainous terrain	64
Radarsat Autocorrelation	- Lack of conformity with terrain	58
ERS Interferometry	- Accurate and good conformity with terrain - Inaccurate in mountainous terrain	12

Based on the results, different scenarios were analysed in order to meet the following criteria:

- Quality at the scale of 1: 50,000 with complete planimetric and altimetric integration
- Digital Elevation Model (DEM) is the main altimetric product
- Minimize development of complex production systems
- Production costs
- A solution open to future developments
- Begin production in the shortest delays

Recommendations:

Recommendations were made to begin production with existing air photography as main data source for planimetry, and to update it with Landsat 7 ortho-images. As new and up to date EO technologies with 3D capabilities become available, such as SPOT5, they will replace air photos. DEMs will be produced by interferometry with ERS 1-2 tandem data in low and moderate terrain, they will comply with CDED product specifications. In mountainous terrain, DEM production will rely on air photography, in such case the planimetry will not be updated in order to ensure coherence with altimetry, for example differences between planimetry and altimetry could occur where glaciers have receded.

Production:

Having all data sources (air photography, ERS, Landsat 7 ortho-imagery) available for the unmapped areas, a five year production plan reflecting the major stakeholder needs in Nunavut and the Northwest Territories was determined. Production began in 2004 according to highest priorities that were set. This plan is revised annually after consulting with the major stakeholders.

The CTIS has a production capacity of 150 map sheets per year, it is injecting over $400, 000 per year in the production of topographic data sets and DEMs for the North. All work is contracted out to qualified Canadian industry. Validation and quality control is done internally. Planimetric data is stored in ArcSDE/Oracle geospatial database from which

topographic maps are generated. CDED are made available on the www.GEOBASE.ca portal.